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The F.O.B.-Retail Price Relationship for Selected Fresh Vegetables

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Abstract.

A recurring question in agriculture is to what degree are grower prices reflected in retail prices. There is a perception that price increases are passed on to retail prices more quickly and completely than are price decreases. This article examines the price behavior of six vegetables; carrots, celery, lettuce, onions, potatoes, and tomatoes. The analysis indicates that for celery, lettuce, onions, and potatoes there is no evidence of price asymmetry. In the case of carrots and tomatoes, however, there is evidence that retail prices show a greater response to f.o.b. price increases.

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A recurring question in agriculture is to what degree are changes in grower prices reflected in changes in retail prices. Recent mergers in the retail industry renew concerns that retailers have gained an ability to increase their margins at growers' expense. Retailers may increase their margins by keeping grower prices lower than they would be if retail competition were greater. Alternatively, retailers can increase margins by raising retail prices, which would decrease demand for growers' output. In either case, an increase in the retailer margin has a negative effect on growers.

Retailers must account for a variety of costs when determining their prices. The largest among them are labor, packaging, and transportation. In the case of produce, the costs are higher than for most other food products and are reflected in the grower-retail price margin. In 1996, the fresh produce margin was 44 percent compared with an average of 30 percent for all foods (Elitzak, 1999, p.10). The greater cost is partly due to the perishability, shrinkage, and the additional labor fresh fruits and vegetables entail. Refrigeration during transportation also contributes to the cost of selling fresh produce.

A portion of the retail price also reflects profit. Fresh produce contributes disproportionately to store-wide profits. They account for 8.7 percent of total supermarket sales but supply about 20 percent of net profit (Elitzak, 1999, p.10). The overall profitability of retail food chains is similar to that of other industries that produce nondurable goods. In 1997, the return on stockholder equity for retail food chains was 17.4 percent. This is only slightly above the 17.0 percent average return on equity for all non-durable goods industries (Elitzak, 1999, p.19).

The transmission of free-on-board shipping-point price (f.o.b.) changes to retail prices is influenced by several factors. First of all, retailers generally attempt to maintain constant prices so as not to lose goodwill with their customers. If a retailer believes that a decrease in f.o.b. prices is temporary, he or she may choose to keep prices constant. For commodities that are less perishable, changes in existing stocks may reduce the effect of supply shocks, such as bad weather, on f.o.b. prices and on retail prices. Finally, any change in a retailer's expenses will cause a change in the f.o.b.-retail margin.

This article examines the price behavior of six vegetables: carrots, celery, lettuce, onions, potatoes, and tomatoes. The variability of f.o.b. and retail prices is first examined. With a

couple of exceptions, the retail price and f.o.b. price variability has declined for all of the selected commodities. The following section examines the retail and f.o.b. price trends over time. Prices rise steadily over time for most of the commodities, except for carrots and tomatoes where it appears that retail price increases accelerated in the 1990's. In the last section a statistical test finds evidence that retail prices for carrots and tomatoes respond more to f.o.b. price increases than to f.o.b. price decreases.

F.O.B. and Retail Price Variance

One way to compare f.o.b. prices with retail prices is by the amount of variance they exhibit. If f.o.b. prices are passed through immediately and completely to retail prices, they should vary together and exhibit the same variance. If retailers do not adjust their prices completely in response to f.o.b. price changes, retail prices should have a smaller variance. There is some reason to expect retail prices to have the smaller variance. There is some cost to changing a retail price, such as the labor involved in repricing fresh produce. The retailer may also lose some goodwill from consumers who prefer stable prices.

The means, standard deviations, and coefficients of variation for retail prices, f.o.b. prices, and the resulting margins for the selected vegetables are listed in table 1. The coefficients of variation are the ratio of the standard deviation to the mean. This statistic provides a convenient way to compare the price variance of different commodities in a way that corrects for the fact that each commodity has a different mean. The data are split in half around 1980. The first number in each cell covers 1960-1979 and the second number covers 1980 to May 1999 (except for onions where the data ends on December 1997). All of the data share a common gap of July 1978 to December 1979 when data were not collected. The f.o.b. price data are supplied from the National Agricultural Statistics Service (NASS) at the U.S. Department of Agriculture, and the retail price data are supplied by the Bureau of Labor Statistics at the U.S. Department of Labor. The data are split in two parts because it spans nearly 40 years during which agricultural markets have changed.

Table B-1 indicates that retail prices vary less than f.o.b. prices. This applies to all of the commodities and for both time periods. This suggests that retailers do not adjust their prices fully to the f.o.b. price changes they encounter on the market. The variance of the retail-f.o.b. margin is similar to the retail price variance for all commodities and for both time periods.

Although retailers are keeping their prices more constant than f.o.b. prices, they are adjusting prices enough to reduce the variance in their margins. This pattern of variability is consistent with asymmetric price adjustment and with markup pricing (Pick et al., 1990).

For all commodities, the variance of the retail prices and the retail-f.o.b. margins drops from the first time period to the second. In most cases, this mirrors a drop in the variance of f.o.b. prices. A more stable supply of fresh produce, likely due to improvements in agricultural techniques and increased imports, contributes to a reduction in the variance in grower prices.

There are, however, two notable exceptions. The variance of f.o.b. prices for tomatoes and lettuce increase in the second time period, albeit only slightly. In the case of lettuce, the increased variance is due to large price increases at the end of 1987 and again from December 1994 to September 1995. A possible explanation for the increased variability of lettuce f.o.b. prices is the growing proportion of the market accounted for by direct contracts between seller and grower. This reduces the size of the residual spot market, which, in turn, tends to increase the variability of prices. For tomatoes, the increased price variability is due to price spikes early in 1990, 1992, and 1996. Although the variance of f.o.b. prices for tomatoes and lettuce increased, the variance of retail prices and the margin still decreased.

F.O.B. and Retail Price Trends

The f.o.b. and retail price trends are similar for all of the selected commodities. Prices for the second time period, 1980-99, are presented in figure B-1. The solid lines in the graphs represent a two-year moving average for retail and for f.o.b. prices. Retail prices consistently rise during this time period. Except for potatoes, f.o.b. prices rise consistently, albeit modestly, as well. The retail-f.o.b. margin increases for all of the commodities.

Although all retail prices rose throughout the time period, they do not all rise equally. Carrots and tomatoes rose particularly rapidly during the 1990's. Lettuce, onions, and celery exhibit a more gradual and constant trend. The retail price of potatoes increases steeply from 1989 to 1990 and then retreats. This is due to an increase in processor demand as described in an earlier article (Love, 1993).

The transmission of f.o.b. prices to retail prices is evident in the dramatic, if ephemeral, price increases in celery in the mid-1990's or in lettuce in 1989 and 1995. Although it appears that prices move together, what is harder to discern from figure 1 is the extent to which f.o.b. price changes are reflected in retail prices. When f.o.b. prices rise, is the increase fully reflected in the retail price? When f.o.b. prices fall, does the decrease get fully passed on to retail prices? Is there a bias in retail prices in that they fully reflect f.o.b. price increases but not the decreases?

Another way of phrasing these questions is whether retail prices respond symmetrically to both f.o.b. price increases and decreases. This is addressed in the next section.

An Analysis of F.O.B-Retail Price Changes

Several studies have examined vertical price transmission in fresh produce. The first question that they address is whether f.o.b. price changes precede retail price changes or vice-versa. One possibility is that fresh produce prices are driven more by shifts in demand than by changes in supply. The chain of events in this situation is that increased demand causes retail prices to rise which, in turn, leads to increases in f.o.b. prices. On the other hand, fresh produce prices may be more affected by fluctuations in supply. In this case, an increase (decrease) in supply causes f.o.b. prices to fall (rise) which, in turn, leads to decreases (increases) in retail prices. All of the studies indicate that f.o.b. price changes precede retail price changes (Ward, 1982; Powers, 1995; Heien, 1980). In other words f.o.b. prices affect retail prices and not the other way around.

In examining the transmission of f.o.b. prices to retail prices, studies reach different conclusions. Studies that look at market prices in specific cities find that the adjustment of retail prices to f.o.b. price changes generally occurs within a month (Ward, 1982; Pick et al., 1990; Powers, 1995). When using national-level data, the adjustment time appears to be much longer – from one to four months (Heien, 1980). This might indicate that all of the markets in the United States, when taken as a whole, react slowly even though some individual markets may react more quickly.

The conclusions about whether retail prices respond symmetrically to f.o.b. (or wholesale) price changes varies between studies as well. One study reports some evidence that retail prices

respond more to wholesale price decreases than increases (Ward, 1982). Other studies, examining the markets in specific cities, find evidence of the opposite (Pick et al., 1990; Powers, 1995).

For this analysis, national data are used to test whether price asymmetries found in specific markets holds for the United States in general. For comparability, the estimation technique used here is similar to that used in previous studies (Ward 1982; Pick et al., 1990; Powers, 1995). The data used are monthly f.o.b. and retail prices from January 1980 to May 1999 (except for onions where the data end on December 1997). Earlier data, though available, are not used because of changes in agricultural markets since 1960.

The estimation equation separately measures the effect of f.o.b. price increases ($FOBUPSUM$) and f.o.b. price decreases ($FOBDOWNSUM$) on the retail price ($RETSUM$). The equation is:

$$RETSUM_t = a_1 FOBUPSUM_t + a_2 FOBDOWNSUM_t + a_3 TREND_t + e_t \quad (1)$$

where:

$$RETSUM_t = RET_t - RET_0$$

$$FOBUPSUM_t = \sum_{i=1}^t (FOBUP_i)$$

$$FOBDOWNSUM_t = \sum_{i=1}^t (FOBDOWN_i)$$

and:

$$FOBUP_i = \begin{cases} FOB_i - FOB_{i-1} & \text{if } FOB_i > FOB_{i-1} \\ 0 & \text{otherwise} \end{cases}$$

$$FOBDOWN_i = \begin{cases} FOB_i - FOB_{i-1} & \text{if } FOB_i < FOB_{i-1} \\ 0 & \text{otherwise} \end{cases}$$

The variable $RETSUM_t$ is the change in the retail price from its initial value (RET_0) to its value at time t (RET_t). For this estimation, the initial value is the price as of January 1980 – the first observation of the dataset. The sum of all of the f.o.b. price increases as of time t ($FOBUP_i$) is $FOBUPSUM_t$. Similarly the sum of all of the f.o.b. price decreases as to time t ($FOBDOWN_i$) is $FOBDOWNSUM_t$. The two variables $FOBUPSUM_t$ and $FOBDOWNSUM_t$ separate out the

effects of price increases and price decreases on the retail price. The sum of the two variables equals the overall change in the f.o.b. price from time 0. The time trend variable is $TREND_t$.

As discussed in the introduction, there are several factors that affect the f.o.b.-retail margin, such as transportation and labor costs. The inclusion of the trend variable accounts for these costs. This implicitly assumes that the costs that are contributing to the margin are changing at a constant rate.

If retail prices respond equally to f.o.b. price increases and decreases, then $a_1 = a_2$ in equation (1). If retail prices respond more to f.o.b. price increases than to f.o.b. price decreases, then $a_1 > a_2$. The opposite holds if retail prices respond more to f.o.b. price decreases.

As indicated by earlier studies, there is a lag between f.o.b. price changes and retail price changes. The lags for each commodity in this study are determined by estimating equation (1) with values of $FOBUPSUM$ and $FOBDOWNSUM$ lagged up to 4 months (Pick et al., 1990). The lags that are different from zero with a confidence level of 20 percent are retained. To test for asymmetry, the coefficients for all of the lags of $FOBUPSUM$ and $FOBDOWNSUM$ are summed up and then compared. If there are m lags of $FOBUPSUM$ and n lags of $FOBDOWNSUM$ then the test is:

$$\sum_{j=0}^m a_{1j} = \sum_{k=0}^n a_{2k} \quad (2)$$

A Durbin-Watson test indicated the presence of autocorrelation in the data. As a result the estimation is done using a linear regression with the Prais-Winsten procedure to correct for autocorrelation. The results are listed in Table B-2. The table also includes a test of equation (2) and the lags used for each commodity.

The number of monthly lags varies across the commodities. The lag for lettuce and carrots is greater for price increases than for price decreases. For the rest of the commodities, there is a greater lag for f.o.b. price decreases. Although this gives some indication of the speed of adjustment, it is not definitive. For example, the lag for f.o.b. price increases in carrots is 3 months. This simply indicates that the lagged coefficients are statistically significant, but does not indicate whether the coefficients are economically significant. It may be that most of the

change in the retail price occurs in the first month. The remaining months, while statistically significant in terms of t -statistics may account for a small remainder of the retail price change.

The coefficients for the f.o.b. price increases (Σa_1) are higher than the coefficients for f.o.b. price decreases (Σa_2) for carrots, onions, and tomatoes. They are nearly equal for celery and lettuce. The coefficient for the f.o.b. price decrease is greater than for the increase for potatoes. Although the gap is larger than for any of the other commodities, it is not statistically significant. Of the six commodities examined, only carrots and tomatoes show a difference that is statistically significant. In other words these are the only commodities that show evidence of price asymmetry. In both cases retail prices respond more to f.o.b. price increases than to f.o.b. price decreases.

Conclusion

There are many factors that affect the f.o.b.-retail price margin. For celery, lettuce, onions, and potatoes there is no evidence of price asymmetry. In the case of carrots and tomatoes, however, there is evidence that retail prices show a greater response to f.o.b. price increases. This behavior has led to concern that retailers have gained enough market power to increase the f.o.b.-retail margin at growers' expense. Finding that a price asymmetry exists is not enough to reach this conclusion. The price asymmetry may be due to increasing expenses, such as labor or transportation, rather than to an increase in retail profits. Precise data on retail expenses, which is not generally available, would be needed to explore the cause of the price asymmetry and why it is evident only for carrots and tomatoes.

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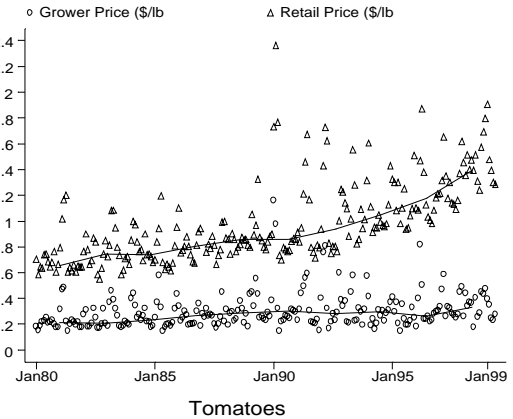
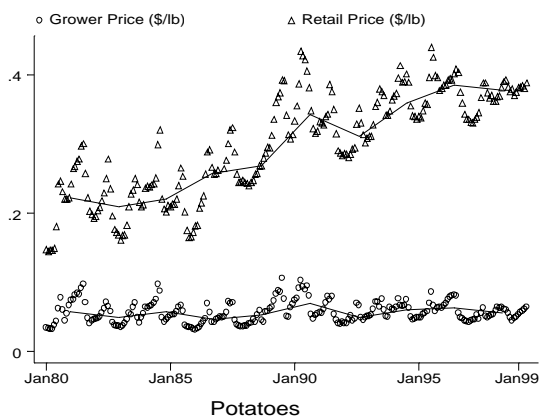
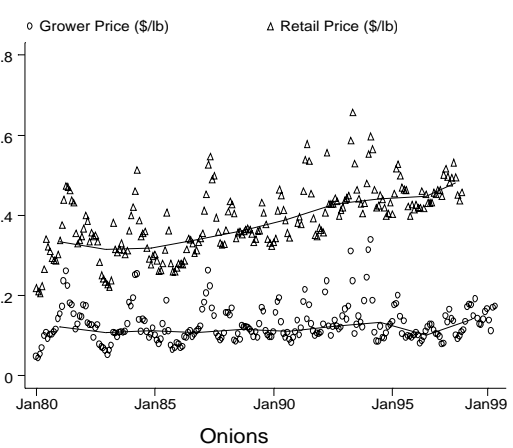
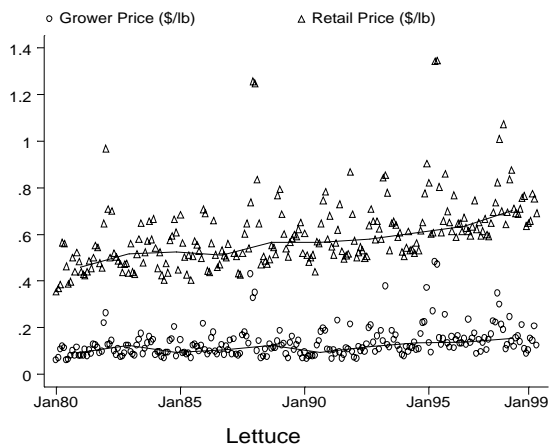
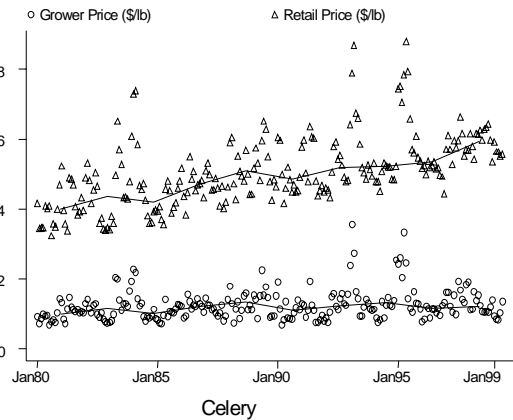
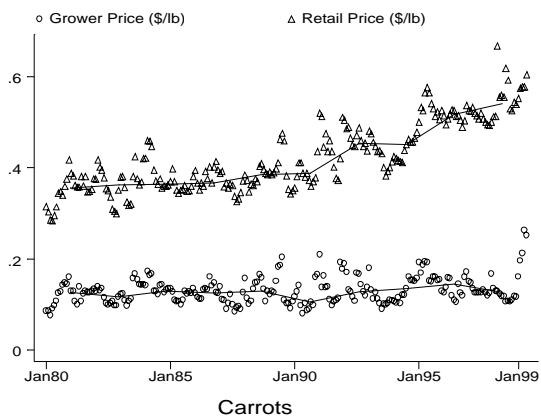
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Table B-1--Variance of retail and F.O.B. prices over time

| Commodity | Time Series | Price Series ¹ | Mean 1960-79/ 1980-99 | Standard Deviation 1960-79/ 1980-99 | Coefficient Of Variance 1960-79 /1980-99 |
|-----------|---|---------------------------|-----------------------------|--|---|
| Carrots | January 1960 to May 1999, Except July 1978 to December 1979 | Retail | 0.197 / 0.423 | 0.055 / 0.075 | 0.279 / 0.177 |
| | | F.O.B. | 0.068 / 0.131 | 0.026 / 0.029 | 0.382 / 0.221 |
| | | Margin | 0.133 / 0.292 | 0.035 / 0.065 | 0.263 / 0.223 |
| Celery | January 1960 to May 1999, Except July 1978 to December 1979 | Retail | 0.205 / 0.505 | 0.070 / 0.098 | 0.341 / 0.194 |
| | | F.O.B. | 0.061 / 0.125 | 0.028 / 0.043 | 0.460 / 0.344 |
| | | Margin | 0.147 / 0.381 | 0.050 / 0.074 | 0.340 / 0.194 |
| Lettuce | January 1960 to May 1999, Except July 1978 to December 1979 and January 1987 to February 1987 | Retail | 0.179 / 0.602 | 0.070 / 0.152 | 0.391 / 0.252 |
| | | F.O.B. | 0.060 / 0.135 | 0.029 / 0.067 | 0.483 / 0.496 |
| | | Margin | 0.121 / 0.467 | 0.052 / 0.108 | 0.430 / 0.231 |
| Onions | January 1960 to December 1997, Except July 1978 to December 1979 | Retail | 0.165 / 0.389 | 0.065 / 0.083 | 0.394 / 0.213 |
| | | F.O.B. | 0.059 / 0.129 | 0.033 / 0.047 | 0.559 / 0.364 |
| | | Margin | 0.107 / 0.260 | 0.045 / 0.063 | 0.421 / 0.242 |
| Potatoes | January 1960 to May 1999, except July 1978 to December 1979 and January 1987 to February 1987 | Retail | 0.098 / 0.299 | 0.037 / 0.074 | 0.378 / 0.248 |
| | | F.O.B. | 0.029 / 0.057 | 0.013 / 0.015 | 0.448 / 0.263 |
| | | Margin | 0.070 / 0.242 | 0.026 / 0.067 | 0.371 / 0.277 |
| Tomatoes | January 1960 to May 1999, except July 1978 to December 1979 and January 1987 to February 1987 | Retail | 0.432 / 0.982 | 0.135 / 0.310 | 0.313 / 0.316 |
| | | F.O.B. | 0.139 / 0.301 | 0.059 / 0.136 | 0.424 / 0.451 |
| | | Margin | 0.298 / 0.681 | 0.092 / 0.243 | 0.309 / 0.357 |

¹ Prices are expressed in \$/lb.

**Figure B-1-- Monthly F.O.B. and retail prices for selected vegetables
January 1980 to May 1999**



**Table B-2--Symmetry tests of retail price response to F.O.B. price changes
for selected vegetables**

| Commodity | No. of Lags Included (Months) | | Price Coefficients (Standard Errors) | | | t- Values for the Test $\Sigma a_1 = \Sigma a_2$ | R- Squared |
|-----------|-------------------------------------|-------------------|---|-------------------------------|----------------------------------|--|---------------|
| | Price Increase | Price Decrease | Σa_1 | Σa_2 | a_3 | | |
| Carrots | 3 | 1 | 1.248 ^c (0.138) | 1.084 ^c (0.128) | -0.0004 (0.0004) | 8.16 ^c | 0.82 |
| Celery | 1 | 2 | 2.007 ^c (0.098) | 2.027 ^c (0.093) | 0.0009 ^c (0.0004) | 0.42 | 0.89 |
| Lettuce | 2 | 1 | 2.296 ^c (0.157) | 2.306 ^c (0.155) | 0.0001 (0.0005) | 0.18 | 0.77 |
| Onions | 1 | 3 | 1.393 ^c (0.111) | 1.361 ^c (0.122) | -0.0008 (0.0017) | 0.04 | 0.60 |
| Potatoes | 1 | 3 | 2.341 ^c (0.279) | 2.555 ^c (0.222) | 0.0008 (0.0011) | 0.39 | 0.69 |
| Tomatoes | 1 | 2 | 1.857 ^c (0.086) | 1.752 ^c (0.082) | -0.0037 ^c (0.0013) | 10.53 ^c | 0.79 |

^c = Significant at the 1 percent level.